Research Paper | Education | E-ISSN No : 2454-9916 | Volume : 9 | Issue : 6 | June 2023

EXPLORING STEM EDUCATION FOR THE VISUALLY IMPAIRED IN INDIA & HOW TECHNOLOGY CAN BE USED TO IMPROVE IT

Ishaan Surve

Research Scholars Program, Harvard Student Agencies, In collaboration with Learn with Leaders

ABSTRACT

Visually Impaired (VI) students in India struggle to pursue a future in Science, Technology, Engineering, and Math (STEM), and many students drop out of science and maths in 8th or after 10th grade. This is primarily because STEM is not engaging enough for these students, and they face multiple challenges in accessing information. VI students are not inherently weaker than sighted students; in fact, they are equally vulnerable to the same misconceptions. However, often because of inaccessible content and poor pedagogy these misconceptions are never cleared leaving them weaker in STEM. Although work has been done by many organizations in India like Xaviers Resource Centre for the Visually Impaired to the Raised Line Foundation which provides 3D tactile models, raised diagrams, braille translated textbooks and audiobooks to visually impaired students, these organizations face difficulty in reaching out to VI students in rural areas. This paper also examines the advantages of gamifying STEM, how it can make it more engaging; help develop the collaborative skills of students and help them grasp concepts. Hence with advances in technology, a gamified platform or product that can be scaled even in rural areas must be developed to encourage VI students to pursue STEM.

KEYWORDS: STEM. Visually Impaired Students, Gamification, Misconceptions.

INTRODUCTION

STEM education plays a vital role in fostering critical thinking, problem-solving, and innovation, equipping students with essential skills for the future. However, visually impaired (VI) students in India face significant challenges in pursuing STEM subjects, leading to high dropout rates and limited opportunities for their academic and professional growth. Inaccessible content, inadequate pedagogy, and the lack of inclusive learning environments contribute to their struggles.

This research article aims to address the existing gaps in STEM education for visually impaired students in India and explore how technology can be leveraged to enhance their learning experience. By examining the experiences of VI students and the efforts made by organizations such as Xaviers Resource Centre for the Visually Impaired and the Raised Line Foundation, the article seeks to shed light on the existing barriers and propose effective solutions.

Furthermore, this paper delves into the advantages of gamifying STEM education and its potential to engage VI students, develop their collaborative skills, and facilitate concept comprehension. The exploration of technology-enabled gamification platforms that can be scaled and made accessible even in rural areas is of paramount importance to encourage visually impaired students to pursue STEM disciplines.

Thesis Statement

Visually Impaired students have the potential to perform well in STEM subjects; however, because of a vision-centered pedagogy in India, they are left behind. This paper examines how technology can make learning STEM more inclusive.

Literature Review

Multiple research papers and literature have been published documenting the problems VI students face while learning. A research paper published in the European Journal of Physics Education and written by Mustafa Şahin, Belkıs, & Ömer (2015) shows that both VI and sighted students are susceptible to the same misconceptions and that VI students are not inherently bad at physics. Another paper written by Ruchi Palan (2020) shows the societal and systematic obstructions which made it difficult for VI students to pursue STEM. The paper written by Dr. Sam Taraporevala discusses why VI students drop STEM and the efforts undertaken by Xaviers Resource Centre for the Visually Challenged. A paper written by Pal & Lakshmanan found that most visually impaired persons do not opt for STEM-related professions and in India, visually impaired people are often influenced by educational institutions, governmental agencies, or non-profits towards specific careers. They are frequently encouraged to work in teaching or in human resource functions. Other popular career areas include medical transcription and telemarketing. Another paper written by a team from IIT Bangalore states that many of these measures have not been accessible to all students in India. Another paper published by the MDPI suggests that gamification of STEM has a positive impact on STEM learning of sighted and VI students. Another paper written by Gesu depicts the successes of an experiment where gamification of STEM for VI students was implemented.

Results & Findings

34% of Indian students choose STEM degrees for their higher education while 80% show interest in pursuing a stem career in the future (World Economic Forum, 2023). It is worth noting that India produces 15,00,000 engineering graduates alone annually and about 45,000 doctors and has over 7500 STEM universities. These statistics show that India is leading the world in the number of STEM graduates and there is no dearth of STEM universities or systemic defects in awareness about STEM among Indians. However, the number of VI students pursuing STEM in India is insignificant when compared to the data that according to the Indian Census of 2011, 50,32,463 people belong to the category of Visual Impairment. In India, almost no VI person pursues Science and Math beyond the 7th grade, or takes up a career in the Science, Technology, Engineering, and Math (STEM) fields (Supriya et al, 2018, p1).

In comparison to sighted students, VI students begin learning STEM without visual inputs and must rely completely on their tactile and hearing senses. However, research has shown that blind students can learn even the most complex topics like the structure of light and image formation using concave or convex mirrors if supported by their teachers and institution. Hence, such students are very vulnerable to developing initial misconceptions. For instance, an experiment conducted showed that of the 8 students, all of them had some misconceptions about force from misunderstanding Newton's Laws of Inertia to difficulty in grasping gravity (Mustafa et al., 2015, pp 25-28). Nevertheless, these misconceptions are also faced by sighted students though those misconceptions are more easily cleared, therefore this study shows that at the beginning VI students are not at an inherent disadvantage for learning physics or science and have similar perceptions as their sighted peers. Therefore, it can be concluded that with effort and support for VI students, they can also gain the same level of insight and conceptual clarity.

There are multiple organisations working to support VI students who want to pursue STEM for example I-STEM, Continual Engine, Vision Empowers, Raised Lines Foundation, and the Xaviers Resource Centre for the Visually Impaired. The Xaviers Resource Centre for the Visually Impaired conducts multiple teacher training sessions across the city. The Raised Lines Foundation is an initiative supported by the Government of India and IIT-Delhi has developed technology to cheaply and efficiently manufacture 3D tactile models which are instrumental for VI students while they are learning vision-oriented scientific concepts.

However, most of these organizations are based in urban areas of India like Mumbai, Delhi, and Bangalore and hence the impact of their activities in rural areas among the VI students is limited. A study when conducted in a school for the blind in Karnataka it was found that the VI students were not exposed to 3-dimensional (3D) models or tactile diagrams. In an experiment designed to introduce tactile diagrams to the students of the 5th standard, 70% of them were not able to relate to a tactile diagram of a flower or the sun, since they had never used such material earlier. Those who have taken Math in high school are exempted from learning Calculus, Geometry, or Trigonometry for their exams - these subjects are, therefore, not taught in these schools. There is no equivalent for these

topics and students often score low marks in the Grade 10 Board examination since they cannot attempt those questions (Supriya et al., 2018, p5).

Gamifying science lessons by implementing game mechanics and elements can increase motivation levels among students and provide them with a safe space to explore the topic constructively without hesitation or fear. In addition, gamification has an inherent social aspect therefore gamification of science will also lead to increased interactions and peer-to-peer learning. Students who engage in gamified learning are more receptive to criticism and more likely to look forward to lessons like these. Students are also likely to be more proactive and it can help in reducing their fear of failure. It also supports project-based and experientially-based learning which are ideal for VI students (Kalogiannakis et al., 2021, p5).

Research published by the Multidisciplinary Digital Publishing Institute (2023) concludes that "universal design for learning principles can be used indirectly to adjust apps for users to utilize the software consistently. This study provides preliminary evaluations for both case studies, which were undertaken with relatively small samples. The first case study revealed that three blind individuals who took part in the review scored an average of 91.7 on the system usability scale. At the same time, the second case study involving the observation of a single individual with ASD also revealed that utilizing the designed app improved performance. Despite the limited sample size, the findings suggest that gamification may effectively encourage and generate commitment among the users with disabilities" (Luis et al., 2023, p1).

Many platforms and websites for sighted students have already implemented elements of gamification like leaderboards, avatars, points, badges, answer streaks, and more for example Quizizz or Khan Academy. However, there is a gap for such a platform for VI students since many of the gamification components are greatly enhanced or totally rely on sight. In such cases, it is necessary for advances in technology to be leveraged in Science and Math Education.

This approach can be highly successful like the Torino case study. Torino is a tangible gamified programming language environment designed for VI students. Torino was introduced to a group of 12 students over 12 sessions in Bangalore. It was noticed that children enjoyed these sessions and would call it the favorite part of their day. Children worked together in teams of two and developed multiple programs successfully. They continued enjoying these sessions throughout hence showing that gamified technologies are effective even once the novelty wears off. It was observed that the children grasped fundamental computation thinking concepts like loops, variables, bugs, and more. (Gesu, 2019, pp 519-520)

CONCLUSION

Visually Impaired students face multiple challenges while trying to pursue an education in Science, Technology, Mathematics, and Engineering. They are more vulnerable to common misconceptions because of poor pedagogy and difficulty in accessing resources. As a result, Visually Impaired students in India are more likely to drop the science stream and are less likely to pursue careers in STEM than their peers. This results in a loss of human resources and potential for India. Although multiple government and non-governmental organizations are working to provide VI students with access to resources in STEM via raised line diagrams, audiobooks, and tactile diagrams, these technologies have still not been made available to VI students in rural areas.

Even though efforts are being made to make STEM accessible to visually impaired students, they are often discouraged and not engaged with the subject. According to my research incorporating gamification and game elements into Visually Impaired pedagogy will help them better understand STEM concepts, make them more receptive to criticism and lead to peer-to-peer learning. It is noteworthy to mention the efforts made in Bangalore to introduce Torino a tangible programming language. It was found that the Visually Impaired students easily grasped programming concepts like loops, variables, and bugs which they at the same time enjoyed tremendously.

REFERENCES

1. Kalogiannakis, M.; Papadakis, S.; Zourmpakis, A.-I. (2021) Gamification in Science Education. A Systematic Review of the Literature. Educ. Sci., 11, 22. https://doi.org/10.3390/educsci11010022
2. Dey S, Y V, Bhushan S, Neerukonda M & Prakash A (2018). Creating an Accessible Technology Ecosystem for Learning Science and Math: A Case Study of Visually Impaired Students in a School, Researchgate
3. Sahin M, Faruk O & Belkis. Using a Force Concept Inventory Test with Visually Impaired and Blind Students. European Journal of Physics Education (Volume 6 Issue 3) pp 25-28
4. Kalogiannakis M, Papadakis S & Zourmpakis A (2023). Analysing the Impact of a Gamification Approach on Primary Students Motivation and Learning in Science Education, Researchgate 10.1007/978-3-031-26876-2_66
5. Aguiar L, Rodriguez F, Aguilar J, Plascencia V, Mendoza L, Valdez J, Pech J, Leon A & Ortiz L (2023). Implementing Gamification for Blind and Autistic People with Tangible Interface, Extended Reality, and Universal Design for Learning: Two Case Studies, Multidisciplinary Digital Publishing Institute
6. Gesu (2019). Computational Thinking as Play: Experiences of Children who are Blind or Low Vision in India, ResearchGate
7. Aguiar, Luis & Rodriguez, Francisco & Aguilar, Jesús & Plascencia, Valeria & Mendoza, Luisa & Valdez, José & Pech, Juan & Leon, Adriana & Ortiz, Luis. (2023). Implementing Gamification for Blind and Autistic People with Tangible Interfaces, Extended Reality, and Universal Design for Learning: Two Case Studies. Applied Sciences. 13. 3159. 10.3390/app13053159.